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Four types of meteoritic material should be found on Mars: 1) micrometeorites, many of which will survive atmospheric entry unmelted, which should fall relatively uniformly over the planet's surface, 2) ablation products from larger meteorites which ablate, break up and burn up in the Mars atmosphere, 3) debris from large, crater forming objects, which, by analogy to terrestrial and lunar impact events, will be concentrated in the crater ejecta blankets (except for rare, large events, such as the proposed C-T event on earth, which can distribute debris on a planetary scale), and 4) debris from the early, intense bombardment, which, in many areas of the planet, may now be incorporated into rocks by geologic processes subsequent to the intense bombardment era.

To estimate the extent of meteoritic addition to indigenous martian material, the meteoritic flux on Mars must be known. Hartmann et. al (1981) estimate that the overall flux is twice that for the Moon and 1.33 that for Earth. For small particles, whose orbital evolution is dominated by Poynting-Robertson (PR) drag (Dohnanyi, 1978), the flux at Mars can be estimated from the Earth flux. The smaller martian gravitational enhancement as well as the decrease in the spatial density of interplanetary dust with increasing heliocentric distance should reduce the flux of small particles at Mars to about 0.33 times the flux at Earth. Because of the smaller planetary cross-section the total infalling mass at Mars is then estimated to be 0.09 times the infalling mass in the micrometeorite size range at Earth.

DIRECT COLLECTION: At Earth the annual infall of meteoritic material hitting the top of the atmosphere is estimated at 16,000 tons, with 12,400 tons of that concentrated in the particles in the $10^{-6}$ to $10^{-2}$ gram mass range (Hughes, 1978). These $10^{-6}$ to $10^{-2}$ gram particles (from 100 to 3000 micrometers in diameter for density 1 gm/cm$^3$) are somewhat larger than the micrometeorites. PR drag is not as efficient in altering the orbits of these particles as it is for the micrometeorites, so the 0.09 reduction factor for the micrometeorites most likely serves as a lower limit. Using this lower limit, a minimum of approximately 1100 tons of meteoritic material in the $10^{-6}$ to $10^{-2}$ gram mass range would be deposited on the top of the martian atmosphere annually, which, if this mass reached the surface as solid material, would be sufficient to cover the planet with a 3 to 4 cm thick layer over the age of the solar system. (This result would be increased by a factor of 4 if the larger Hartman et al.(1981) flux is used). On earth, particles in this mass range are normally melted or volatilized on atmospheric entry. *However Mars, because of its low gravitational acceleration combined with sufficient atmospheric density to provide deceleration, is probably the most favorable site in the solar system for unaltered survival (and thus collection) of micrometeorites.* We have made new calculations of the interactions of these micrometeorites with the martian atmosphere using the micrometeorite deceleration model first used by Whipple (1950) and the upper atmospheric density profile for Mars derived from Viking entry measurements (Seiff and Kirk, 1976). Particles of the same density, shape, and thermal characteristics entering at velocities near the martian escape velocity are heated to a peak temperature only half that experienced on Earth entry at earth escape velocity. Although most particles larger than 75 to 100 micrometers in diameter are melted on Earth atmosphere entry, the cutoff size for melting on Mars entry would be about 13 times larger, or 1000-1300 micrometers in diameter.

The concentration of micrometeorites in martian soils depends on the fraction of them which survive atmospheric entry as solid material, the regolith depth and the total accumulation time. For illustrative purposes only, we assume that all of the micrometeorites smaller than 3000 micrometers survive atmospheric entry in some form as solid material, the martian regolith has an average depth of 10 m (consistent with Arvidson's (1986) estimate of a planetary meters/$10^9$ years erosion estimate based on crater preservation), and micrometeorites have been accumulating at the present estimate rate for the past $4 \times 10^9$ years. For these conditions, a 10 gram average soil sample would have been mixed with about 5000 micrometeorites greater than 100 micrometers in diameter and 10 micrometeorites greater than 800 micrometers in diameter. Micrometeorites in this size range which have survived atmospheric entry are normally not collected at earth. These larger particles from Mars orbital distance are likely to sample different sources than the smaller micrometeorites collected at 1 a.u. in the cosmic dust sampling program on earth (Flynn, 1987; Zook and McKay 1986).

COLLECTING SITES FOR MICROMETEORITES: Martian surface processes (weathering and wind erosion, transport, and deposition) may fractionate the dust by size, density or composition providing regions of increased local concentration, suggesting even more suitable sites for micrometeorite sampling than

the average soil. *These sites may include placer catch basins or lag surfaces which may accumulate high density micrometeorites or their derived and altered minerals. Conversely, low density micrometeorites may be wind segregated along with finer martian dust and may constitute a relatively coarse-grained component of that dust at its deposition sites.* By analogy with Antarctica, meteorites of all size ranges may be relatively concentrated in martian polar regions, although the concentrations mechanisms may be different.

MICROMETEORITES AS A TOOL: Micrometeorites added to martian regolith after atmospheric deceleration below hypervelocities may still be identifiable by petrographic or chemical means. While they may be relatively quickly destroyed by martian weathering, the chemical signature, particularly siderophiles, may persist in the soils, as they have in the lunar regolith (Anders et al., 1973). The possibility that detectable micrometeorites and their remains can be found in the martian soils depends on the relative rates of infall, weathering and alteration, transportation, and mixing, and these rates are not yet known reliably enough to allow us to predict with certainty whether identifiable micrometeorites will be found. *However, assuming that micrometeorites could somehow be identified in returned soil samples, this addition of micrometeorite material to the uppermost martian regolith at a constant rate could conceivably provide a powerful tool for tracking rates of erosion, deposition, and weathering.* Some attempt should be made to collect soils from different geologic sites (catch basins, lag surfaces, flat high plains, valley bottoms, etc.) so as to provide a variety of soils of different sedimentary environments. One of the important differences among these environments might be the proportion of petrographically or chemically identifiable micrometeorites mixed into the soil.

MARTIAN AGGLUTINATES: *If, as we calculate, micrometeorites are all slowed down by the martian atmosphere, and assuming that most lunar agglutinates are made by micrometeorite impacts, no analogous martian agglutinates would be expected* (unless there were an era in which the atmosphere was considerably less dense than at present). However, many types of impact glasses would be expected from larger impacts, and some of these glasses may resemble lunar agglutinates in some respects.

MARTIAN SOIL MATURITY: Gault and Baldwin (1970) have estimated a minimum impact crater size of 50 meters, taking into account fragmentation and ablation of the incoming projectiles as well as atmospheric deceleration. The smallest craters noted in Viking orbiter images are about 100 meters in diameter (Blasius, 1976), but smaller craters beyond the resolution limit of the photographs may still be present. Dycus (1969) predicts that projectiles as small as 10 gm would still form craters. However, craters too small to be seen from the orbiter are not apparent in Viking lander images. Impact gardening associated with the 50 meter and larger craters predicted by Gault and Baldwin (1970) would determine regolith turnover rates and cause comminution of rocks into soils. The addition of micrometeorites would affect the petrology and chemistry of martian soil. Weathering and sedimentary processes on Mars would also process the regolith components. The overall effect would be to make an exceedingly complex regolith. *A new maturation scale will be necessary for martian regolith. This scale will have to include terms which reflect (1) impact reworking, (2) addition of micrometeorites, and (3) martian surface weathering and alteration.* For example, if concentration mechanisms can be factored out, the abundance of micrometeorites (identified petrographically or chemically) in a soil layer might be directly related to its near-surface exposure time in a manner analogous to the abundance of agglutinates in lunar soils. In addition to soil evolution through maturation, physical mixing of soils of differing maturities should be common.

*The first returned soil samples from Mars should provide the opportunity for recovery and analysis of unaltered micrometeorites larger than any sampled on earth, assessment of the magnitude of the meteoritic component, and possibly an estimate of the rate of erosion and regolith production on the planet. This micrometeorite population may be quite different from the population sampled at 1 a.u. The extent of regolith gardening, small crater production, and agglutinate production (if any) will also provide clues to the evolution of the martian atmosphere density over time.*

REFERENCES: Anders, E. et al.(1973). Moon, 8, 3-24.; Arvidson, R. E. (1986) in Dust on Mars II, LPI Tech. Report 86-09, 9.; Blasius, K. R. (1976) Icarus 29, 343-361.; Dohnanyi, J.S. (1978). In Cosmic Dust (ed. J.A.M. McDonnell) Wiley, New York, 527-605.; Dycus, R. F. (1969) Publications of the Astronomical Soc. of the Pacific. 81, 399-414.; Flynn, G.J. (1987). Atmospheric Entry Heating: A Criterion to Distinguish Between Asteroidal and Cometary Sources of InterPlanetary Dust, submitted to Icarus.; Gault, D.E., and Baldwin (1970). EOS Trans. AGU, 51, 343.; Hartmann, et. al. (1981) In Basaltic Volcanism on the Terrestrial Planets, LPI, p 1049-1127.; Hughes, D.W. (1978). In Cosmic Dust (ed. J.A.M. McDonnell) Wiley, New York, 123-185.; Seiff, A. and Kirk, D. B (1976) Science, 194, p.1300-1302.;Whipple, F. L. (1950) Proc. Nat. Acad. Sci.,36,p.687-695. Zook, H.A. and McKay, D.S. (1986). LPSC XVII, 977-978.

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